RADIO FIELD-STRENGTH MEASUREMENT

By R. L. SMITH-ROSE, D.Sc., Ph.D., Member.

The subject of radio field-strength measurement is of direct interest in connection with all applications of radio-wave technique. Furthermore, since radiocommunication, broadcasting, and to a lesser extent navigational aids, concern many countries other than that in which the service originates, it is important to ensure that there is international agreement on the methods of measurement used and on the results obtained with the equipment available. The British National Committee for Scientific Radio has been active in this field in connection with the General Assemblies of the Union Radio Scientifique Internationale since 1934, when a comprehensive review of the then existing methods of measuring radio field-strengths was presented. Two years later, the National Physical Laboratory conducted a comparison between the various field-strength measuring sets then available in Great Britain for wavelengths between 7 and 1 500 m (40 Mc/s and 200 kc/s). The results of this comparison showed that while in the wavelength band 6–10 m (50–30 Mc/s) the measurements on different sets agreed to within $\pm$ 20% of the mean value, greater divergences were obtained at longer wavelengths; and in the range 100–500 m (3–0·6 Mc/s) the departures from the mean value of field strength ranged from $-$ 30% to $+$ 60%. An examination by the U.S. Bureau of Standards of a number of commercial equipments for field-strength measurement at wavelengths within the range 200–500 m (frequencies 1 500–600 kc/s) showed that special precautions were necessary to ensure the attainment of an absolute accuracy within 20%. Apart from the introduction of the use of a shot-noise diode in place of thermal-agitation noise in the first tuned circuit, for adjusting the amplifier in a measuring set to a standard gain, there is no evidence from the published literature that any appreciable advance on the position described above has been made in the past ten years.

What has been done, however, is to improve the technique of field-strength measurement at wavelengths below 10 m (frequencies above 30 Mc/s), and to extend the measuring technique to the shortest wavelengths now in common use for radio applications. These advances have taken place broadly along two main lines: (*a*) the separation of the calibrating unit from the field-strength measuring set, and its replacement by a method of producing a known field by radiation; and (*b*) the replacement of current or voltage measurement which is used at frequencies below about 600 Mc/s, by a measurement of power at frequencies exceeding this value.

With regard to the first, equipment has been developed at the National Physical Laboratory whereby radio field strengths at all wavelengths from about 30 m (10 Mc/s) to about 50 cm (600 Mc/s) can be produced and measured, and the methods are equally applicable to the measurement of continuous-wave and pulse-modulated radiation. The second line of development indicates that for wavelengths below about 50 cm (frequencies above about 600 Mc/s) it is more practicable to measure the power received in an aerial or waveguide system of which the gain and directional receiving properties are known than to adopt the more usual methods common at lower frequencies.

At the present time, most of the types of equipment referred to above have been developed on an experimental basis for the use of research laboratories, and there is little commercially produced equipment available even for use at the lowest radio frequencies. While it is considered that field-strength measurement should nowadays be possible to a reliability of the order of 1 or 2 db (say 10 to 25%), the absence of adequate inter-comparisons of the techniques on both a national and an international basis naturally leads to some lack of confidence on the part of the user who may have important consequences dependent upon the results of such field-strength measurements.

Dr. Smith-Rose is at the Department of Scientific and Industrial Research.

BIBLIOGRAPHY

(1) WATSON-WATT, R. A., and SMITH-ROSE, R. L.: "Report to Commission I on Existing Methods of Measuring Radio Field Intensity," *Proceedings of the General Assembly of the Union Radio Scientifique Internationale*, London, 1934, **4**, p. 166. (This paper includes a bibliography to the literature on field-strength measurement up to 1934.)

(2) GREEN, A. L., and WOOD, H. B.: "A Field Intensity Set," Commonwealth of Australia C.S.I.R. Radio Research Board, 1935, Report No. 6, p. 19.

(3) MUMFORD, A. H., and BARKER, P. L.: "A Field Strength Measuring Set using Thermal Agitation Noise as the Calibrating Source," *Post Office Electrical Engineers' Journal*, 1935, **28**, p. 40.

(4) WRIGHT, F. M.: "Marconi Ultra Short Wave Field-Strength Measuring Equipment," *Marconi Review*, 1937, No. 67, p. 14.

(5) VON ARDENNE, M.: "Field Strength Measuring Apparatus for Broadcasting Waves," *E.N.T.*, 1937, **14**, p. 293.

(6) British National Committee: "Report to Commission I on the Measurement of Radio Field Intensity (May 1938)," *Proceedings of the General Assembly of the Union Radio Scientifique Internationale*, Venice, 1938, **5**, p. 28.

(7) DIAMOND, H., NORTON, K. A., and LAPHAM, E. G.: "On the Accuracy of Radio Field-Intensity Measurement at Broadcast Frequencies," *National Bureau of Standards Journal of Research*, 1938, **21**, p. 795; *Proceedings of the General Assembly of the Union Radio Scientifique Internationale*, Venice, 1938, **5**, p. 262.

(8) MCPETRIE, J. S., and PRESSEY, B. G.: "A Method of Using Horizontally-Polarized Waves for the Calibration of Short-Wave Field-Strength Measuring Sets by Radiation," *Journal I.E.E.*, 1938, **83**, p. 210.

(9) COLEBROOK, F. M., and GORDON-SMITH, A. C.: "The Design and Construction of a Short-Wave Field-Strength Measuring Set," *ibid.*, 1939, **84**, p. 388.

(10) BURGESS, R. E.: "Noise in Receiving Aerial Systems," *Proceedings of the Physical Society*, 1941, **53**, p. 293.

(11) MCPETRIE, J. S., and SAXTON, J. A.: "Theory and Experimental Confirmation of Calibration of Field-Strength Measuring Sets by Radiation," *Journal I.E.E.*, 1941, **88**, Part III, p. 11.

(12) COLEBROOK, F. M., and GORDON-SMITH, A. C.: "A Method of Calibrating a Field-Strength Measuring Set," *ibid.*, 1941, **88**, Part III, p. 15.

(13) NORTH, D. O.: "The Absolute Sensitivity of Radio Receivers," *R.C.A. Review*, 1942, **6**, p. 332.

(14) COLEBROOK, F. M., and GORDON-SMITH, A. C.: "The Design of Ultra-Short-Wave Field-Strength Measuring Equipment," *Journal I.E.E.*, 1943, **90**, Part III, p. 28.

(15) FRIIS, H. T.: "Noise Figures of Radio Receivers," *Proceedings of the Institute of Radio Engineers*, 1944, **32**, p. 419.

(16) MCPETRIE, J. S., PERRY, W. E., and FORD, L. H.: "Sensitivity Calibration of Receivers," *Wireless Engineer*, 1945, **22**, p. 6.

(17) CLAYTON, R. J., HOULDIN, J. E., LAMONT, H. R. L., and WILLSHAW, W. E.: "Radio Measurements in the Decimetre and Centimetre Wavebands," *Journal I.E.E.*, 1946, **93**, Part III, p. 116.

(18) OATLEY, C. W.: "Ultra-High-Frequency Measurements," *ibid.*, 1946, **93**, Part IIIA, p. 205.

(19) GRACE, A. C.: "A Radio Field-Strength Measuring Set for Use in the Frequency Range 400–4 000 Mc/s," *ibid.*, 1946, **93**, Part IIIA, p. 1325.

(20) PRESSEY, B. G., and ASHWELL, G. E.: "A Pulse Field-Strength Measuring Set for Very High Frequencies," *ibid.*, 1946, **93**, Part IIIA, p. 1359.

(21) ARCHER-THOMSON, H., and HICKIN, E. M.: "Radio Technique and Apparatus for the Study of Centimetre-Wave Propagation," *ibid.*, 1946, **93**, Part IIIA, p. 1367.

(22) SAXTON, J. A., and GRACE, A. C.: "A Field-Strength Meter and Standard Radiator for Centimetre Wavelengths," *ibid.*, 1946, **93**, Part IIIA, p. 1426.

(23) KOMPFNER, R., HATTON, J., SCHNIEDER, E. E., and DRESEL, L. A. G.: "The Transmission-Line Diode as Noise Source at Centimetre Wavelengths," *ibid.*, 1946, **33**, Part IIIA, p. 1436.